

**What is claimed is:**

1. Surface-modified nanoparticles whose surface is covered completely or near-completely with

5 (A) modifying groups which

- are attached covalently to the surface via at least one linking functional group (a) and
  - contain at least one inert spacer group (b) and
  - contain at least one reactive functional group (c)
- 10 which is connected via the group (b) to the group (a) and is inert toward the reactive functional groups of the surface to be modified,

(B) modifying groups which

- are attached covalently to the surface via at least one linking functional group (a) and
- 15
- contain at least one inert group (d) attached to the surface via group (a) having a smaller hydrodynamic volume  $V_H$  than the inert spacer group (Ab), and

20 (C) modifying groups which

- are attached covalently to the surface via at least one linking functional group (a) which contains at least one silicon atom,
  - contain at least one inert group (e) attached to
- 25 the surface via group (a), and
- have a smaller hydrodynamic volume  $V_H$  than the modifying group (A).

2. Surface-modified nanoparticles as claimed in claim 1, wherein the hydrodynamic volume  $V_H$  can be determined by means of photon correlation spectroscopy or estimated using the equation

5 
$$V_H = (r_{cont}/2)^3$$

in which  $r_{cont}$  is the effective contour length of a molecule.

3. Surface-modified nanoparticles as claimed in claim 1 or 2, wherein the reactive functional groups of the surface to be modified are hydroxyl groups.

4. Surface-modified nanoparticles as claimed in any of claims 1 to 3, wherein the linking functional group (Aa) contains at least one silicon atom.

5. Surface-modified nanoparticles as claimed in any of claims 1 to 4, wherein the inert spacer group (Ab) is an at least divalent organic radical R.

6. Surface-modified nanoparticles as claimed in any of claims 1 to 5, wherein the reactive functional group (Ac) is activable thermally and/or with actinic radiation.

7. Surface-modified nanoparticles as claimed in claim 6, wherein the thermally activable reactive functional group (Ac) is a blocked isocyanate group and the reactive functional group (Ac) which can be

activated with actinic radiation is selected from the group consisting of groups containing at least one carbon-carbon multiple bond.

5 8. Surface-modified nanoparticles as claimed in any  
of claims 1 to 7, wherein the linking functional group  
(Ba) is selected from the group consisting of ether,  
thioether, carboxylate, thiocarboxylate, carbonate,  
thiocarbonate, phosphate, thiophosphate, phosphonate,  
10 thiophosphonate, phosphite, thiophosphite, sulfonate,  
amide, amine, thioamide, phosphorhide,  
thiophosphorhide, phosphonphide, thiophosphonamide,  
sulfonamide, imide, hydrazide, urethane, urea, thio-  
urea, carbonyl, thiocarbonyl, sulfone and sulfoxide  
15 groups.

9. Surface-modified nanoparticles as claimed in any  
of claims 1 to 8, wherein the inert group (Bd) and the  
inert group (Ce) are monovalent organic radicals  $R^2$ .

20

10. Surface-modified nanoparticles as claimed in  
claim 9, wherein the monovalent organic radicals  $R^2$  are  
selected from the group consisting of aliphatic,  
cycloaliphatic, aromatic, aliphatic-cycloaliphatic,  
25 aliphatic-aromatic, cycloaliphatic-aromatic, and  
aliphatic-cycloaliphatic-aromatic radicals.

11. Surface-modified nanoparticles as claimed in any  
of claims 1 to 10, wherein the inert groups (Ab), (Bd),

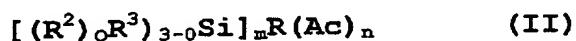
and (Ce) contain at least one at least divalent functional group and/or at least one substituent.

12. Surface-modified nanoparticles as claimed in any  
5 of claims 1 to 11, preparable by reacting the reactive functional groups of the surface of nanoparticles for modification with

- (A) at least one modifier containing
  - at least one reactive functional group (a) which  
10 is reactive toward the reactive functional groups of the surface to be modified,
  - at least one inert spacer group (b) and
  - at least one reactive functional group (c) which  
15 is connected via the group (b) to the group (a) and is inert toward the reactive functional groups of the surface to be modified,
- (B) at least one modifier containing
  - at least one reactive functional group (a) which  
20 is reactive toward the reactive functional groups of the surface to be modified, and
  - at least one inert group (d) having a smaller hydrodynamic volume  $V_H$  than the inert spacer group (Ab), and also
- (C) at least one modifier having a smaller  
25 hydrodynamic volume  $V_H$  than the modifier (A), containing
  - at least one reactive functional group (a) which contains at least one silicon atom and is reactive toward the reactive functional groups of the

surface to be modified, and  
- at least one inert group (e).

13. Surface-modified nanoparticles as claimed in  
5 claim 12, wherein the modifier (A) is selected from the  
group consisting of silanes of the general formula II:



in which the indices and the variables have the  
following definitions:

10 m and n are integers from 1 to 6;

o is 0, 1 or 2;

Ac is a group activable thermally and/or with  
actinic radiation, as defined above;

15 R is an at least divalent organic radical, as  
defined above;

R<sup>2</sup> is a monovalent organic radical, as defined  
above; and

R<sup>3</sup> is a hydrolyzable atom or group.

20 14. Surface-modified nanoparticles as claimed in  
claim 13, wherein the hydrolyzable atom R<sup>3</sup> is selected  
from the group consisting of hydrogen atoms, fluorine  
atoms, chlorine atoms, and bromine atoms and the  
hydrolyzable group R<sup>3</sup> is selected from the group  
25 consisting of hydroxyl groups and monovalent organic  
radicals R<sup>4</sup>.

15. Surface-modified nanoparticles as claimed in  
claim 14, wherein the monovalent organic radical R<sup>4</sup> is

selected from the group consisting of groups of the general formula III:



in which the variable Y stands for an oxygen atom or a carbonyl group, carbonyloxy group, oxycarbonyl group, amino group -NH- or secondary amino group -NR<sup>2</sup>- and the variable R<sup>2</sup> is as defined above.

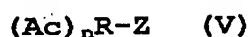
16. Surface-modified nanoparticles as claimed in any of claims 13 to 15, wherein the silanes (A) of the general formula II are obtainable by

- (1) reacting polyisocyanates with blocking agents and with silanes of the general formula IV:



in which the variable Z stands for an isocyanate-reactive functional group and the variables R, R<sup>2</sup> and R<sup>3</sup> are as defined above; or

- (2) reacting compounds of the general formula V:



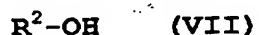
in which the index n and the variables Ac, R, and Z are as defined above with silanes of the general formula VI:



in which the index m and the variables R, R<sup>2</sup> and R<sup>3</sup> are as defined above.

17. Surface-modified nanoparticles as claimed in any of claims 12 to 16, wherein the modifier (B) is selected from the group consisting of hydroxyl-

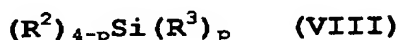
containing compounds of the general formula VII:



in which the variable  $R^2$  is as defined above.

5 18. Surface-modified nanoparticles as claimed in claim 17, wherein the hydroxyl-containing compounds of the general formula VII are primary aliphatic alcohols.

19. Surface-modified nanoparticles as claimed in any  
10 of Claims 12 to 18, wherein the modifier (C) is selected from the group consisting of silanes of the general formula VIII:



15 in which the index  $p = 1, 2$  or  $3$ , and the variables  $R^2$  and  $R^3$  are as defined above.

20. Surface-modified nanoparticles as claimed in any of claims 1 to 19, wherein the nanoparticles for modification are selected from the group consisting of  
20 metals, compounds of metals, and organic compounds.

21. Surface-modified nanoparticles as claimed in claim 20, wherein the metals are selected from main groups three to five and transition groups three to six  
25 and one and two of the periodic system of the elements, plus the lanthanoids.

22. Surface-modified nanoparticles as claimed in claim 20 or 21, wherein the compounds of the metals are

oxides, oxide hydrates, sulfates, hydroxides or phosphates.

23. A process for preparing surface-modified  
5 nanoparticles as claimed in any of claims 1 to 22,  
which comprises reacting the nanoparticles for  
modification in a first stage with at least one  
modifier (A) and also in a second stage with at least  
one modifier (B) and in a third stage with at least one  
10 modifier (C) or in the second stage with at least one  
modifier (C) and in the third stage with at least one  
modifier (B) or in the second stage with at least one  
modifier (B) and at least one modifier (C).

15 24. The process as claimed in claim 23, wherein the  
modifiers (A), (B), and (C) are used in an amount which  
is sufficient for the complete or near-complete  
coverage of the surface of the nanoparticles for  
modification.

20

25 25. A process for producing modified nanoparticles as  
claimed in any of claims 13 to 22, which comprises  
jointly hydrolyzing and condensing at least one  
modifier (A) of the general formula II and at least one  
25 modifier (C) of the general formula VIII and then  
reacting the resultant polycondensates with at least  
one modifier (B).

26. A dispersion comprising surface-modified



nanoparticles as claimed in any of claims 1 to 22 and/or surface-modified nanoparticles prepared by the process as claimed in any of claims 23 to 25 in aprotic solvents and/or reactive diluents.

5

27. The dispersion as claimed in claim 26, wherein the aprotic solvents and/or reactive diluents have with regard to the modifying groups (A) and (B) a Flory-Huggins parameter  $\chi > 0.5$ .

10

28. The dispersion as claimed in claim 26 or 27, having, based on its total amount, a solids content of at least 30% by weight.

15

29. The dispersion as claimed in claim 28, comprising at least one additive selected from the group consisting of polymeric and oligomeric binders, crosslinking agents, color and/or effect pigments, organic and inorganic, transparent or opaque fillers,

20

other nanoparticles different than the nanoparticles of the invention, UV absorbers, light stabilizers, free-radical scavengers, devolatilizers, slip additives, polymerization inhibitors, photoinitiators, initiators of free-radical or cationic polymerization, defoamers,

25

emulsifiers, wetting agents, dispersants, adhesion promoters, leveling agents, film formation auxiliaries, sag control agents (SCAs), rheological control additives (thickeners), flame retardants, siccatives, dryers, antiskinning agents, corrosion inhibitors,

waxes; and flatting agents.

30. The use of the surface-modified nanoparticles as  
claimed in any of claims 1 to 22, of the surface-  
5 modified nanoparticles prepared by the process as  
claimed in any of claims 23 to 25, or of the dispersion  
as claimed in any of claims 26 to 29 for producing  
coating materials, adhesives, sealants, compounds based  
on engineering plastics, or curable compositions.